THE DESIGN OF A TETHERED BALLOON SYSTEM TO EXPLORE THE MARTIAN ATMOSPHERE

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ABSTRACT

Recent developments have led to a renewed interest in the planet Mars. Several missions to the red planet have been scheduled for the near future, and more missions are being considered. One aspect of Mars that is attracting scientific interest is its atmosphere. Up to now in situ measurements of the atmosphere of Mars have only been carried out during the entry and descent of landing vehicles and by surface-dwelling systems.

The authors have carried out a study to show the feasibility of using a small tethered aerobot on a mission to Mars. The goal of the aerobot is to measure pressure, temperature and humidity at several altitudes in the boundary layer of the atmosphere (up to 100 m) for a prolonged period. The total mission costs are constrained such that the mission is affordable within the budget of Delft University of Technology. The mass and volume are also subject to stringent constraints to make the system as attractive as possible to serve as an instrument on a wide range of missions to Mars. Furthermore care should be taken to minimise the risks the system poses to the host mission.

The study resulted in two design concepts of a balloon system tethered to a lander on the surface. The balloon of the first concept is able to carry 10 atmospheric packages, capable of measuring pressure, temperature and humidity. These packages are equally spaced along the tether and send their data along the cable to the data handling subsystem of the lander. Power is supplied using the same cable. The total mass of the system is lower than 10 kg, and the volume is smaller than 15 L.

The second design concept utilises the same balloon system, but carries a camera to take high resolution pictures of the direct surroundings of the lander. These pictures could for instance be used to support the navigation of a Mars rover.

The thin atmosphere of Mars made designing a small, light-weight balloon a challenge. A small increase in lift-off weight drastically increases the required size and weight of the total system. Because of this, integration of the two design concepts (camera and a string of atmospheric packages) proved to be unfeasible. The deployment proved to be another challenge, as the balloon material (linear low-density polyethylene) is only 6 microns thick. The best solution was to use an inflatable conical structure attached to the bottom of the balloon, to avoid damage to the balloon or instruments on the lander during inflation. Simulations on the cable and wind forces were carried out to predict system requirements both for the balloon system and Mars lander.

Aspects of the design were tested by sending a camera to 30 km altitude on Earth, where temperature and pressure are representative of the conditions the balloon will face on Mars, and by testing a tethered balloon at 100 m altitude lifting a camera and atmospheric package.

This study has shown that a low-cost, low-risk aerobot, carrying instruments on a mission to Mars, is feasible and able to carry out meaningful science.